p/ROM Card Simplifies Computer Diagnosis

Shlomo Waser

Monolithic Memories, Incorporated
Computer Systems Division
Sunnyvale, California

p/ROM Card Simplifies Computer Diagnosis

Shlomo Waser

Monolithic Memories, Incorporated
Computer Systems Division
Sunnyvale, California

When an input device storing a diagnostic program is not working, or its interface with the computer is out of order, the diagnostic might as well not exist; but if the diagnostic is stored internally in a p/ROM, it is independent of external device failures

A method of loading diagnostic programs into a computer's main memory requires no mechanical input device, and the computer needs to be operational only at a minimal level. The diagnostic, on a programmable read-only memory (p/ROM) card, is most useful when the computer or its interface is not operating properly, in which case it may be impossible to load the diagnostic program using conventional approaches, such as a teleprinter or a disc storage unit. Using p/ROMs for storing diagnostic programs offers some additional benefits, such as speed. Loading is faster than is possible with a high speed disc, yet cost is much lower. Reliability of p/ROMs is greater than for paper tape, which is subject to tearing. Last, but not least, is the convenience

obtained by using a single card as an input device rather than a bulky teleprinter or a heavy disc unit.
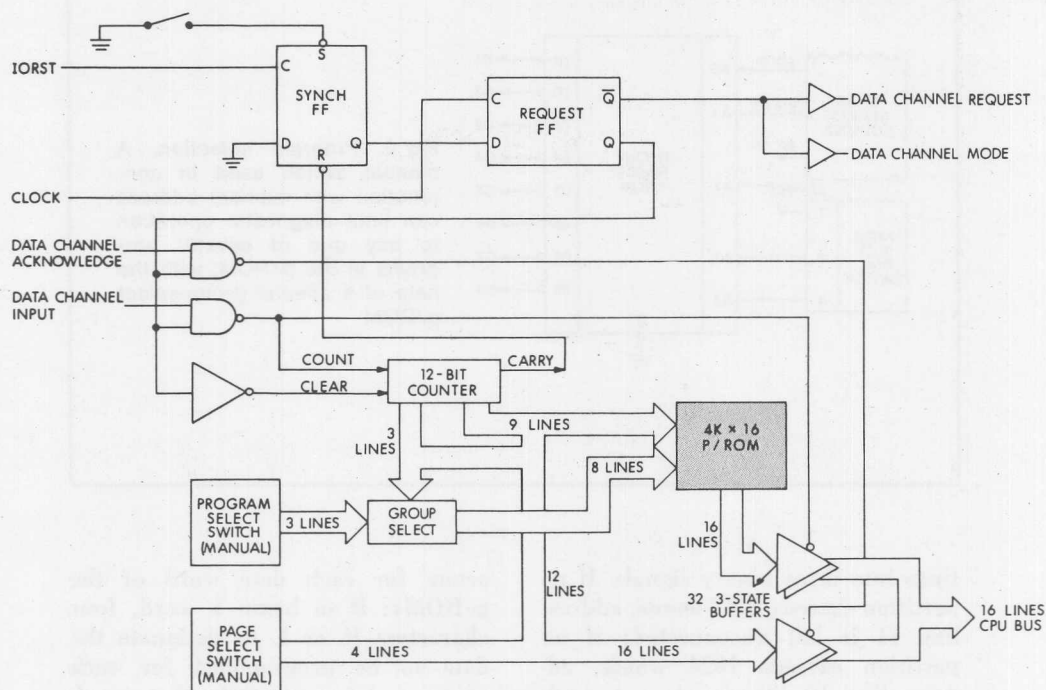
The p/ROM card described in this article is used on the MMI 300 computer; however, the concept is applicable to any mini or microcomputer with direct memory access (DMA), sometimes called data channel or DCH. The MMI 300 is a 16-bit microprogrammable computer with 16 bidirectional bus lines timeshared between address and data. Only four control lines are necessary to direct movement of data from p/ROM card into main memory.

Each p/ROM card has an array of 32 p/ROMs, each storing 512 words of four bits, for a total of 4096 x 16, which store the binary images of several diagnostic programs. Two selector switches on the

card select one of several diagnostic programs to be loaded into the memory, and the 4-kiloword memory page into which the program is loaded. The card communicates with main memory via DMA, which requires a minimum of control lines and also avoids moving data through the CPU, which may be inoperative.

Data Flow

Loading of a program into main memory is initiated with the AUTO-LOAD momentary switch (Fig 1, upper left). Activating the switch clears the p/ROM address counters and sets the Data Channel Request and Data Channel Mode signals. This forces the CPU to execute the DMA-IN sequence in its microprogram upon completing the current

Fig 1 Diagnostics in p/ROM. Internal storage of diagnostics is easier, faster, and cheaper than trying to load them from an external device. It is also more reliable, because it works even if the interface is down

instruction. DMA-IN is one of several sequences parallel to the normal Fetch routine; an external signal, such as Interrupt from a peripheral unit or a switch activation on the front panel, causes one of these sequences to take priority over Fetch.

The first microinstruction generates the Data Channel Acknowledge signal, with which the p/ROM card gates the current p/ROM address onto the bus; the CPU then loads the bus contents into the memory address register. In the next microinstruction the CPU sends the Data Channel Input signal with which the p/ROM card gates the contents of the current address onto the bus, from which the CPU loads it into memory. The trailing edge of Data Channel Input increments the p/ROM address counter. As long as Data Channel Request and Data Channel Mode are active the CPU repeats this DMA-IN sequence, stopping when the carry from the address counter clears the Data Channel Request line.

Program Selection

Since most diagnostic programs require only a portion of the 4096 x 16 space on the card, a provision was made to handle various size programs. Implementation uses a selector switch and a 32 x 8 p/ROM which decodes the boundaries of the selected program.

Partitioning of the p/ROM memory is determined by the word size of the p/ROM chips. The card described here is made of p/ROMs with 512 words each. Obviously, the total number of words in different programs accommodated cannot exceed 4096; likewise, individual partitions should be multiples of 512 words in length.

To load the first program the program select switch is set to 0. Activating the AUTO-LOAD switch clears the p/ROM address counter. Now the output G1 of the group select p/ROM (Fig 2) is activated. This signal enables only the p/ROMs corresponding to addresses between 0 and 511 in the Exerciser

program. Once the DMA is requested, G1 stays active until the first 512 words are loaded into memory. As soon as the next word is to be loaded, incrementing the p/ROM address counter activates bit 9 and thus G2, and they remain active between the addresses 512 to 1023. In a similar fashion G3 and G4 are activated for their corresponding addresses. Remember that the p/ROM is only transferring the program into main memory, as from a peripheral; the diagnostic is not yet being executed.

Normally, to address a 4096-word memory would require 12 address bits. Nine of these (bits 0 to 8) would be common to all the 512-word chips, and the other three (bits 9 to 11) would select one of the eight 512 x 16-chip groups. For partitioning, however, the eight chip-select lines come from the group select p/ROM, which is driven by the three high-order address lines and by a manual program select switch that encodes up to eight set-
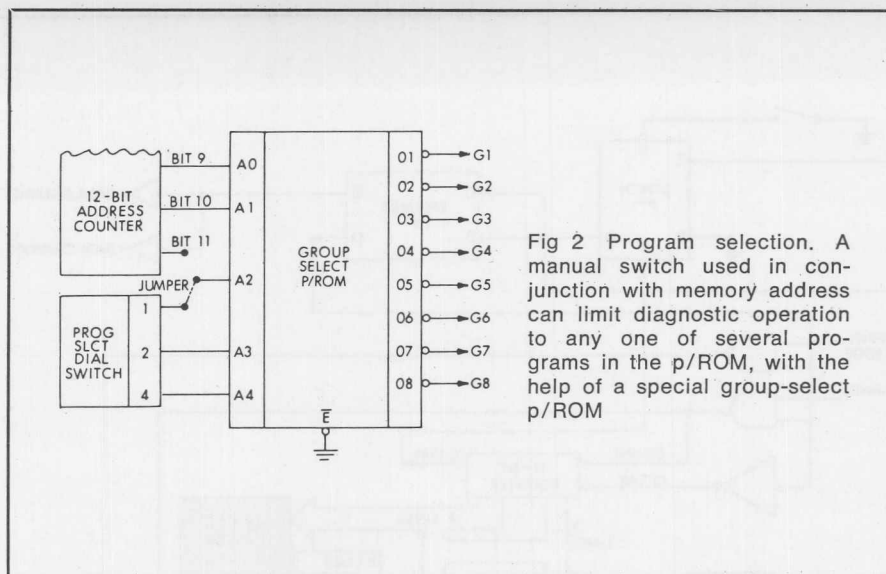
Fig 2 Program selection. A manual switch used in conjunction with memory address can limit diagnostic operation to any one of several programs in the p/ROM, with the help of a special group-select p/ROM

tings into three binary signals. If no partition exceeds 2048 words, address line 11 is left unconnected; if no partition exceeds 1024 words, address line 10 likewise is not used. Otherwise these three high-order address lines are connected to the low-order inputs of the small p/ROM. Similarly the three outputs of the manual switch are connected to the three high-order p/ROM inputs. (Since the small p/ROM has only five inputs, it cannot have three low-order *and* three high-order inputs; the one in the middle is both. The conflict is settled by a jumper connected to either counter bit 11 or select switch 1, depending on the particular application.)

Suppose, for example, the large p/ROM card is to store four diagnostic programs of different sizes: Exerciser, requiring almost 2048 words; Instruction Test, almost 1024; Memory Test, fewer than 512; and Loader, also fewer than 512. Since the largest program size is less than 2048 words, address line 11 is not connected; address lines 9 and 10 go to the small p/ROM inputs A0 and A1; switch outputs 2 and 4 go to p/ROM inputs A3 and A4; and p/ROM input A2 is connected by a jumper to switch output 1, as shown in Fig 2.

Loading the diagnostic program into the p/ROM should be easy—most p/ROM manufacturers provide an automatic method to program their p/ROMs; paper tape is the common input medium. The usual format on the tape consists of six ASCII char-

acters for each data word of the p/ROMs: B to begin a word, four characters H or L to designate the data to be programmed for each corresponding output in that word, and F to delimit the end of each word. No addresses are given in the tape, except at the start of the tape where the letter S corresponds to address zero. Data words which follow the letter S are addressed sequentially, starting from zero, until the letter E (for "END") terminates the automatic programming. Software generates the paper tape input for the automatic programmer.

In this specific case the computer word is 16 bits wide while the p/ROM word is only 4 bits wide. Therefore, each block of 512 words in the diagnostic program is loaded into four p/ROMs—the four least-significant bits (LSBs) of the first 512 words into the first p/ROM, the four next LSBs into the second p/ROM, and so on. For diagnostic programs longer than 512 words, more p/ROM tapes are generated until the entire routine is converted—four tapes and four p/ROM chips for each block of 512 or fewer words.

Conclusion

The p/ROM card described here offers an inexpensive and reliable solution to the problem of loading a defective computer with diagnostic programs. It is a very effective tool in two areas: first, in bringing up systems, and secondly, in expediting field repair.   □